THE SYNTHANE COAL-TO-GAS PROCESS: A PROGRESS REPORT

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INTRODUCTION

National energy needs demand the development of a supplemental natural gas from coal. This is of deep concern to the pipeline industry, the gas industry, and the coal industry. What is needed is an operable economic process. The Bureau of Mines at Bruceton, Pa., has developed a process for making a high-Btu gas from coal--the Synthane Process. The steps of gasification, gas purification, and methanation have been tested to the point that a prototype plant is being designed.

THE OVERALL PROCESS

The Synthane Process is shown schematically in figure 1. The main components are the gasifier, the shift converter, the purification system, and the catalytic methanator. The water-gas shift step is commercial, and no work has been done on this step. The Bureau hot carbonate purification work was developed about 10 years ago 1/ and has been adopted commercially but is no longer being researched. The gasifier and methanator are being tested at the present time.

The purified gas has a heating value of about 500 Btu/cu ft before methanation and a heating value exceeding 900 Btu/cu ft after methanation.

The Gasifier

The gasifier is shown in figure 2. It is a fluid-bed type, operating at 40 atmospheres (600 psia) and up to 1,000° C (1,830° F). The coal, 70% through 200 mesh, is dropped through the pretreater with oxygen and steam (or CO_2) at 400° C (750° F), where it is rendered non-caking. The decaked coal then falls into the carbonization zone and finally to the gasification zone where it is gasified with steam plus oxygen.

Results of the latest tests with free-fall pretreatment are shown in table 1, where the data are compared with assumptions made for the economic study. The data shown have met or exceeded all assumptions made, considering the limitations of our 6-foot-high gasifier with respect to throughput. A unique feature of the process is that almost 60% of the methane in the product gas is made in the gasifier.

The Methanator

The development of the methanation step has proceeded on two processes: the hot-gas-recycle (HGR) 2/ and the tube-wall reactor (TWR). 3/ Development

1/ J. H. Field, et al. Pilot Plant Studies of the Hot-Carbonate Process for Removing Carbon Dioxide and Hydrogen Sulfide. BuMines Bull. 597, 44 pp. 1962.

2/ A. J. Forney, R. J. Demski, D. Bienstock, and J. H. Field. Recent Catalyst Developments in the Hot-Gas-Recycle Process. BuMines R.I. 6609, 32 pp., 1965.

3/ W. P. Haynes, J. J. Elliott, A. J. Youngblood, and A. J. Forney. Operation of a Sprayed Raney Nickel Tube Wall Reactor for Production of a High-Btu Gas. Preprint of Division of Fuels Chemistry of ACS Meeting, Sept. 1970, Chi., Ill.

at present is in the TWR system. This system is shown in figure 3. Within the methanator, the gas (fresh feed plus recycle) passes up over the outside of seven 2-inch diameter tubes which are thermal sprayed with Raney nickel to a thickness of 0.020 to 0.030 inch. The tubes are baffled to increase turbulence of the gas flow. Results of the latest test are shown in figure 4. The present test has been operating 2900 hours, equivalent to 240,000 SCF of high-Btu gas/lb of catalyst. The desired sulfur content before methanation must be less than 1 ppm; in methanation tests at Bruceton the sulfur content of the feed gas has been as low as 10 ppb.

NEW DEVELOPMENTS

Pretreatment

The throughput of the gasifier would be improved if a coal coarser than 70% through 200 mesh could be gasified. Attempts were made to pretreat such coals, but nothing coarser than 30% through 200 mesh could be pretreated in the present free-fall unit. The pretreater was changed back to the fluid-bed system used originally. 4, 5/ Figure 5 shows a schematic of the new system. Coal 20 mesh by 0 was pretreated easily with less oxygen than needed for the free-fall system.

Gasification

The change to a coarser coal permitted an increase in the linear velocity; thus the coal feed could be raised equivalent to about 50 $lb/hr\text{-}ft^3$.

A change in the bed height of the gasifier from 6 to 12 feet is scheduled, which would raise significantly the throughput per gasifier internal cross-sectional area.

Methanation

Because the tubes were difficult to change in the reactor shown in figure 3, where the Ranel nickel was sprayed on the exterior of 2-inch-diameter tubes, the reactor was revised. We sprayed the catalyst on the inside surface of 4-inch-diameter tubes. This revised unit is being tested. Since then we have started development of a new method of spraying the catalyst, with the objective of coating the inside of tubes as small as 1-5/8 inch in diameter and as long as 30 feet. Such an improvement now appears feasible because we found we could use a wire spray gun instead of the powder spray gun, which had many limitations.

Pressure

Extrapolation of results of tests at 20, 30, and 40 atmospheres show that pressures of 70 atmospheres should result in a yield of methane exceeding 5 scf/lb coal feed. This higher pressure would reduce the oxygen requirement by one-fourth. The prototype plant will be designed for 70 atmospheres to verify this conclusion.

4/ A. J. Forney, R. F. Kenny, S. J. Gasior, and J. H. Field. Fluid-Bed Gasification of Pretreated Pittsburgh Seam Coal. Preprint of Division of Fuels Chemistry of ACS, September 1966, New York, N.Y.

5/ A. J. Forney, R. F. Kenny, S. J. Gasior, and J. H. Field. The Production of Non-Agglomerating Char From Coking Coal in a Continuous Fluid-Bed Reactor. Preprint of Division of Fuel Chemistry of ACS, September 1964, Chicago, Ill.

CONCLUSION

The Synthane Process steps of gasification, purification, and methanation have been proven at the Bruceton laboratories. Recent improvements of these steps have helped the overall process and should make the process more attractive economically. Although the design of the prototype plant must be fixed soon, continued research is expected to improve the process.

TABLE 1. - Latest test results of the Bruceton gasifier compared to assumptions made in the economic report

Assumptions	Plant test			
Throughput	Test 196	199	197	204
25 lb/hr-ft^3	32	30	43	36
Product Gas				
16.2 SCF/lb	18.0	18.6	16.2	17.3
18.0 SCF/lb MAF	19.4	20.2	17.5	19.0
CH_4				
4.45 SCF/lb	4.40	4.65	4.16	4.51
4.95 SCF/lb MAF	4.74	5.04	4.48	4.97
CH_4 27.5%	24.4	24.5	25.4	25.9
Carbon Conversion				
To Gas 66.8%	66.3	71.0	59.0	64.9
Steam Decomposition 39%	38	32	32	37

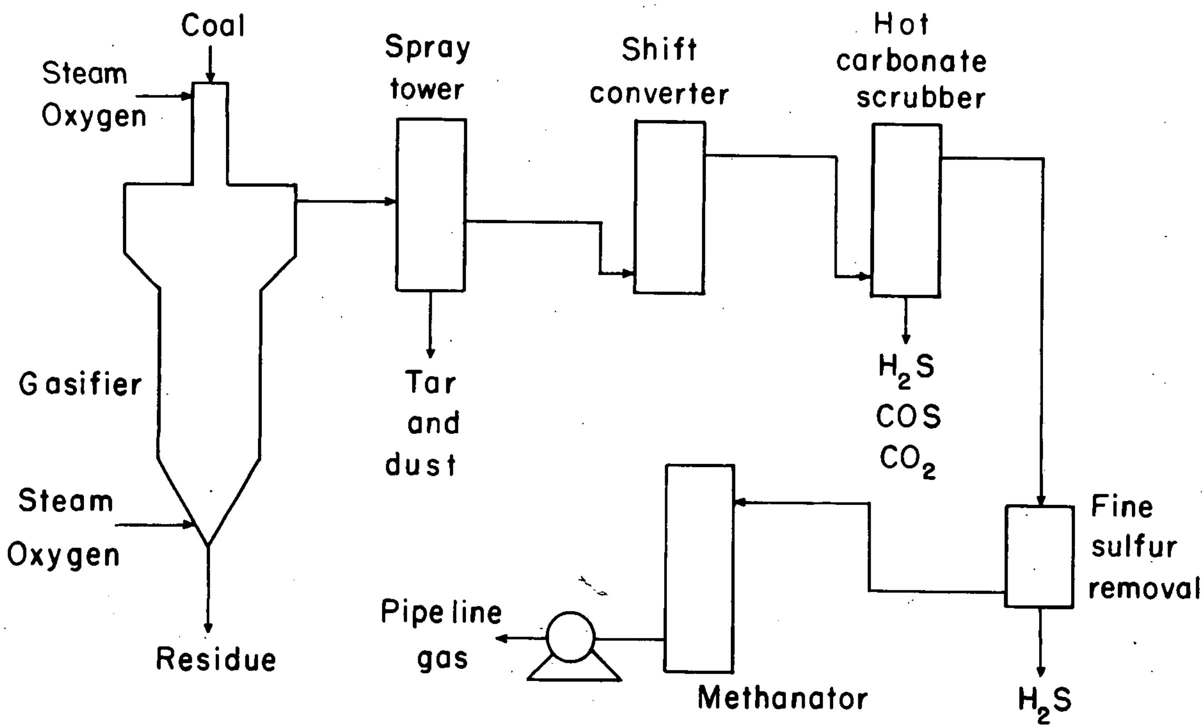

Figure 1. System Used to Make High-Btu Gas From Coal

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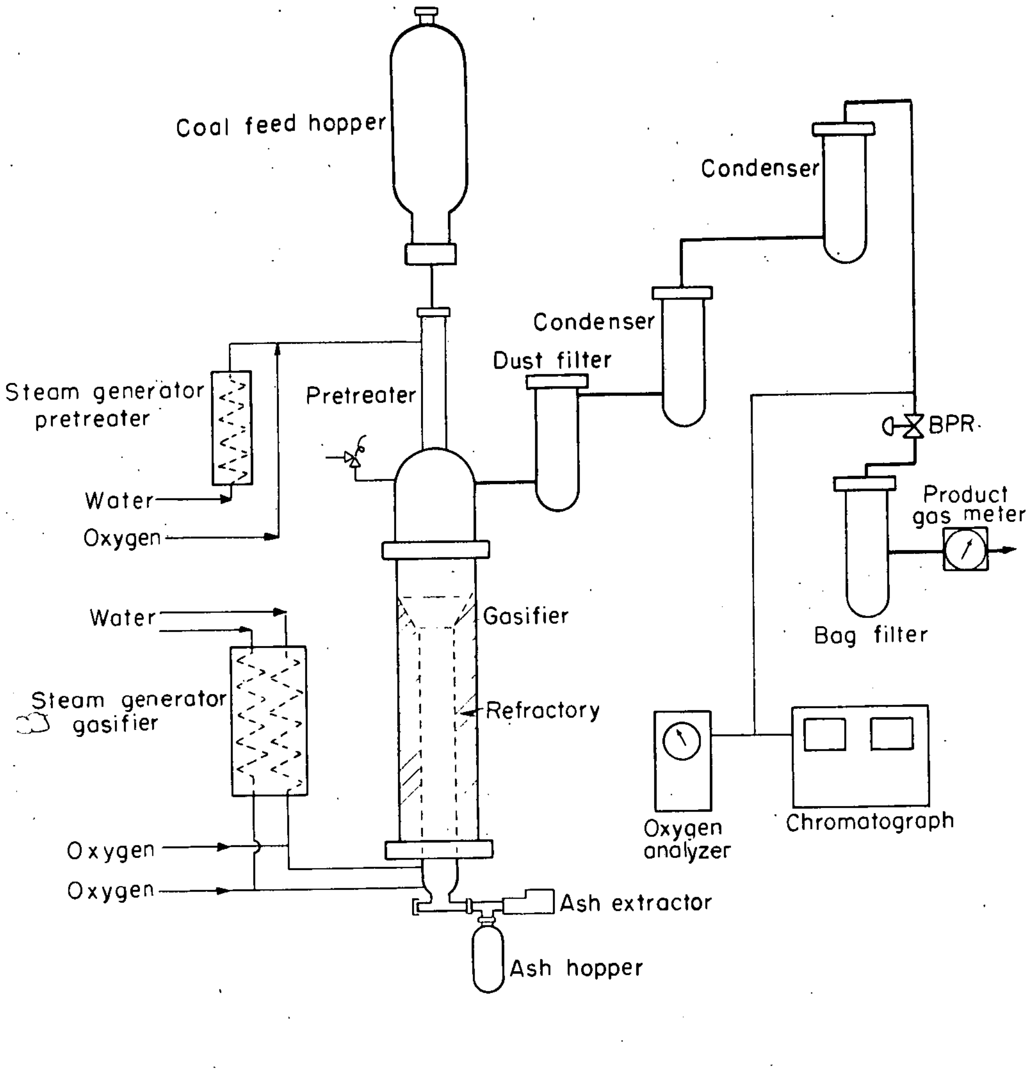

Figure 2. 40-Atmosphere Fluid-Bed Gasifier
(free-fall pretreater)

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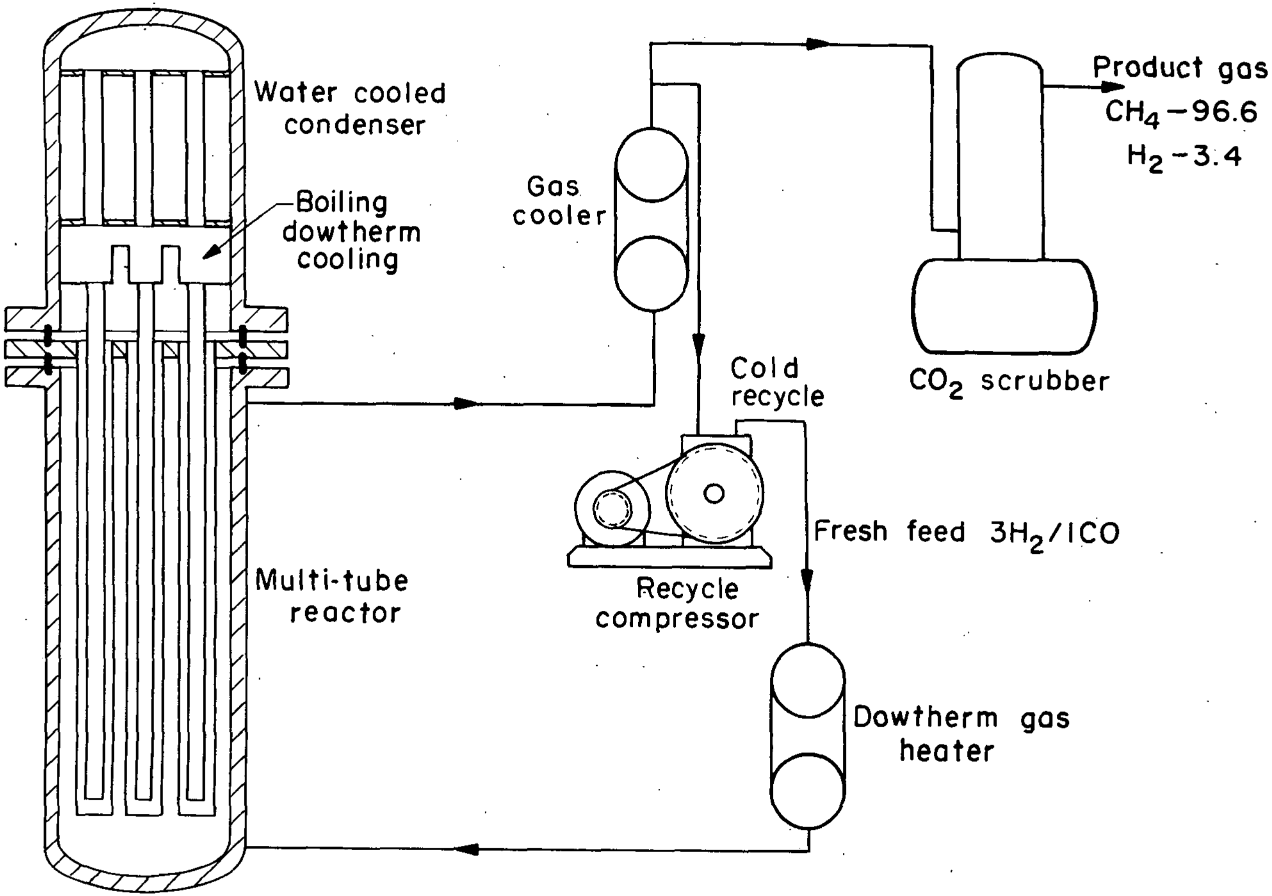

Figure 3. Simplified Flowsheet of Pilot Plant for Producing High-Btu Gas

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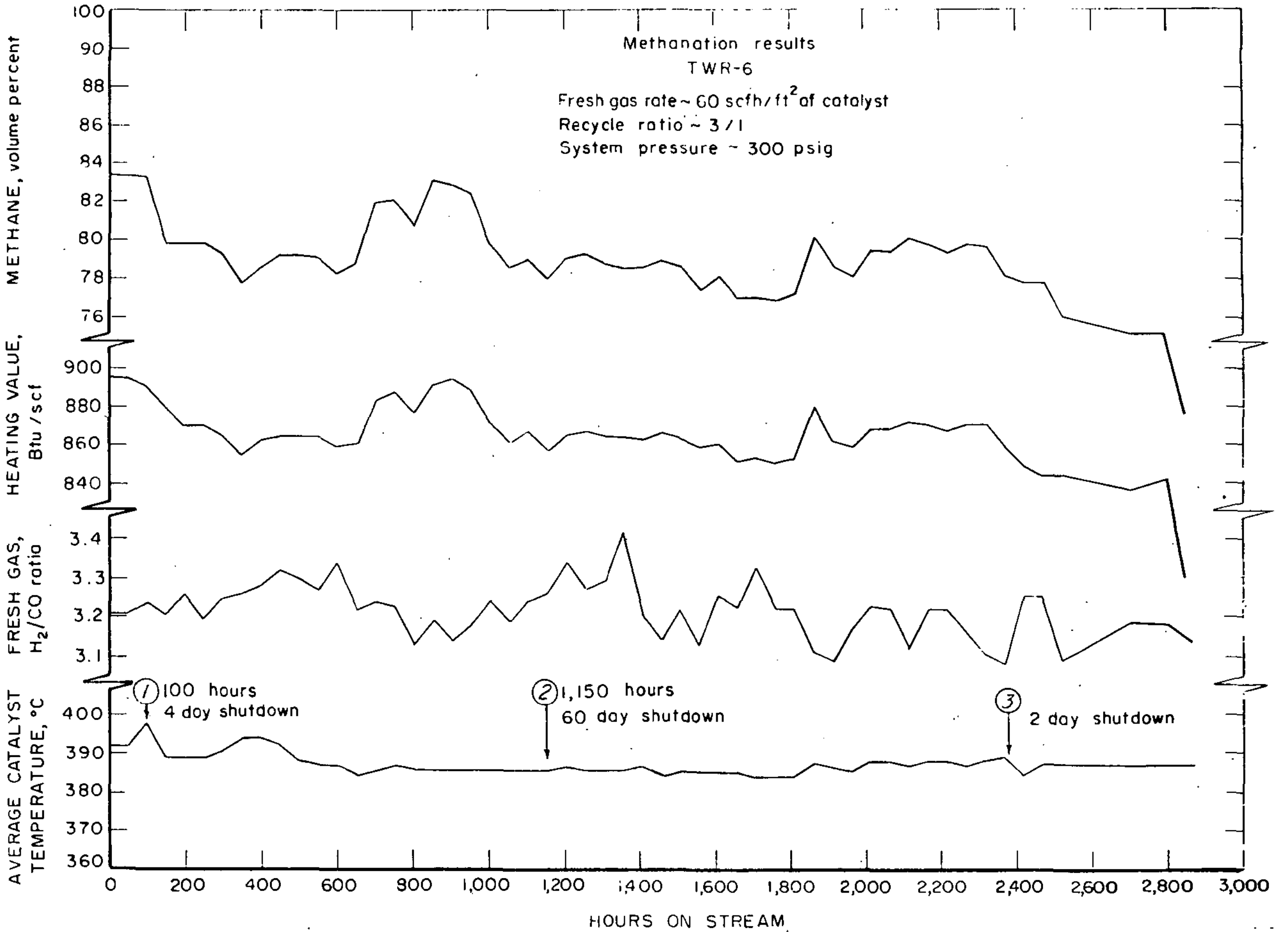

Figure 4. Methanation Test Results

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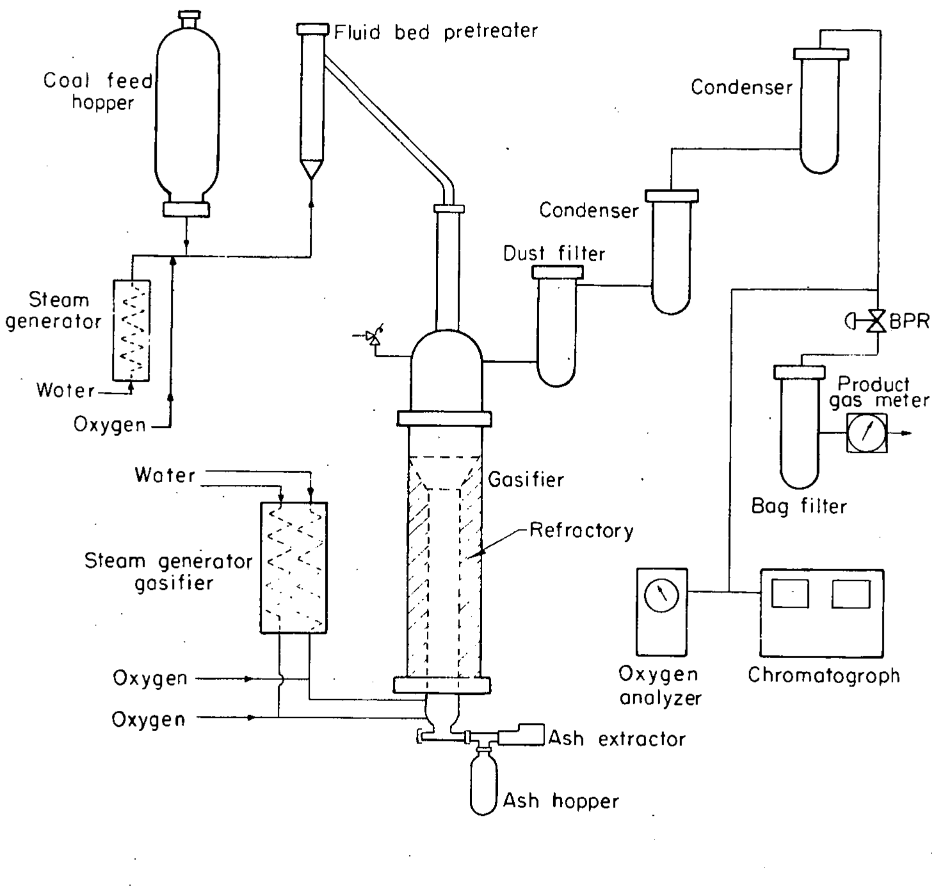

Figure 5. 40-Atmosphere Fluid-Bed Gasifier (fluid-bed pretreater)